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APPLICATION NUMBER: ***60/482,026***
FILING DATE: ***June 24, 2003***
RELATED PCT APPLICATION NUMBER: ***PCT/US04/20215***

Certified by

Jon W Dudas

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PTO/SB/16 (10-01)
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14772 U.S. PTO
60/482026
06/24/03

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No.	EV 335563305 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
John A.	Foote	18810 Halyard Pointe Ln. Cornelius, NC 28031

☑ *Additional inventors are being named on the* 1 *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

OPTICAL SENSOR FOR MEASURING CHARACTERISTICS AND PROPERTIES OF STRANDS

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ENCLOSED APPLICATION PARTS ***(check all that apply)***

☑ Specification *Number of Pages* 6

☑ Drawing(s) *Number of Sheets* 2

☑ Application Data Sheet. See 37 CFR 1.76

☐ CD(s), Number

☐ Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☑ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☑ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 01-0265

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): $80.00

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☑ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: ____________

Respectfully submitted,

SIGNATURE ____________ Date 06/24/2003

TYPED or PRINTED NAME W. Thad Adams, III

REGISTRATION NO. *(if appropriate)* 29,037

Docket Number: 3102/1

TELEPHONE 704-375-9249

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

02527 U.S. PTO

7

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FEE TRANSMITTAL for FY 2003

Effective 01/01/2003. Patent fees are subject to annual revision.

☑ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 80.00

Complete if Known	
Application Number	
Filing Date	06/24/2003
First Named Inventor	Foote
Examiner Name	
Art Unit	
Attorney Docket No.	3102/1

METHOD OF PAYMENT *(check all that apply)*

☐ Check ☐ Credit card ☐ Money Order ☐ Other ☐ None

☑ Deposit Account:

Deposit Account Number: 01-0265

Deposit Account Name: Adams Evans PA

The Director is authorized to: *(check all that apply)*

☑ Charge fee(s) indicated below ☑ Credit any overpayments

☐ Charge any additional fee(s) during the pendency of this application

☐ Charge fee(s) indicated below, except for the filing fee

to the above-identified deposit account.

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	750	2001	375	Utility filing fee	
1002	330	2002	165	Design filing fee	
1003	520	2003	260	Plant filing fee	
1004	750	2004	375	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	80

SUBTOTAL (1) ($) 80

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X		=	
Independent Claims		- 3** =		X		=	
Multiple Dependent						=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	84	2201	42	Independent claims in excess of 3
1203	280	2203	140	Multiple dependent claim, if not paid
1204	84	2204	42	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	410	2252	205	Extension for reply within second month	
1253	930	2253	465	Extension for reply within third month	
1254	1,450	2254	725	Extension for reply within fourth month	
1255	1,970	2255	985	Extension for reply within fifth month	
1401	320	2401	160	Notice of Appeal	
1402	320	2402	160	Filing a brief in support of an appeal	
1403	280	2403	140	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,300	2453	650	Petition to revive - unintentional	
1501	1,300	2501	650	Utility issue fee (or reissue)	
1502	470	2502	235	Design issue fee	
1503	630	2503	315	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	750	2809	375	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	750	2810	375	For each additional invention to be examined (37 CFR 1.129(b))	
1801	750	2801	375	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) ____________

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0

SUBMITTED BY				(Complete *(if applicable)*)	
Name (Print/Type)	W. Thad Adams, III	Registration No. (Attorney/Agent)	29,037	Telephone	704-375-9249
Signature				Date	06/24/2003

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PROVISIONAL APPLICATION COVER SHEET
Additional Page

PTO/SB/16 (02-01)
Approved for use through 10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Docket Number	3102/1

INVENTOR(S)/APPLICANT(S)		
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Number 1 of 1

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Provisional Patent Application

OPTICAL SENSOR FOR MEASURING CHARACTERISTICS AND PROPERTIES OF STRANDS

Technical Field and Background of the Invention

This invention relates to an optical sensor used to measure, for example, the characteristics and properties of mono-filament or multi-filament yarn composed of man-made or natural fibers, as well as wire and other strand-like materials. Characteristics and properties of the yarn that can be measured include, but are not limited to, interlace, diameter/denier, density, filament orientation and broken filaments. The sensor according to the present invention can be used for real-time measurements in both on-line and off-line yarn measurement applications.

The main components of the optical sensor are a Digital Signal Processor (DSP), a LED and a linear array consisting of a number of pixels. The yarn is positioned between the LED and the linear array such that a shadow of the yarns width is projected about the mid point of the linear array as shown if Figure 1. The characteristics and properties of the yarn are present in the image of the yarn projected on to the linear array. The yarns image is captured in the linear array and represented by the composite analog values of the individual pixels where 1) at least one or more pixels have been blocked by the yarns shadow and 2) at least one or more pixels on 1each side of the yarns shadow are completely unblocked. The analog value of each pixel is digitized using the DSP's onboard digital-to-analog converter. The digitized pixel data is then processed by the DSP to extract the specific yarn characteristics and properties of interest.

Summary of the Invention

Therefore, it is an object of the invention to provide an optical sensor that permits measurement of a wide variety of yarn characteristics and properties.

It is another object of the invention to provide an optical sensor that takes advantage of recent developments and refinements in optical digital detection.

It is another object of the invention to provide an optical sensor that is operable in both on-line and off-line applications.

It is another object of the invention to provide an optical sensor that is operable in real-time.

Brief Description of the Drawings

Some of the objects of the invention have been set forth above. Other objects and advantages of the invention will appear as the invention proceeds when taken in conjunction with the following drawings, in which:

Figure 1 is a schematic view of an optical sensor according to a preferred embodiment of the invention illustrating the measurement geometry of the system, and

Figure 2 is a schematic view according to a preferred embodiment of the invention and illustrating a technique for increased resolution.

Description of the Preferred Embodiment and Best Mode

Referring now specifically to the drawings, an optical according to the present invention is illustrated in Figure 1.

A linear array consists of numerous, closely spaced pixels, for example, 128 pixels. Other array configurations are also possible. Each pixel contains a photo diode and appropriate sampling circuitry. The photo diode produces an analog voltage proportional to the level of incident light. The analog output voltage from the photo diode is integrated, or sampled, over a timed interval controlled by the linear array's electronic shutter. Thus, the analog output of each pixel is proportional to the level of the light on the photo diode and the length of time the shutter is open.

To capture an image, the shutter of the linear array is enabled by opening it, which resets each pixel's integrator and then allows each integrator to integrate its respective photo diode output. Each integrator will continue to integrate the photo diode output until the shutter is disabled by being closed. This places each integrator in a hold mode whereby the output of each pixels integrator is "latched".

The "latched" analog value of each pixel can now be read from the linear array by supplying a clock pulse to select each successive pixel and then reading its analog output. Preferably, the analog output is connected to the DSP's analog-to-digital (A-to-D) converter which digitizes each pixels analog output.

The DSP provides all the timing and control signals for the array and the strobing of the LED. Images are captured in the linear array and processed by the DSP at 10,000 frames per second.

The shutter speed, i.e., the length of time the shutter is open, is controlled by a closed loop function in the DSP whereby unblocked pixels are used to provide feedback on the incident light level. This automatic shutter control compensates for variations in the LED light level, ambient light level and for any contamination such as finish oil on the yarn being measured that might build up on the lens of the sensor. Without this automatic shutter control function, the measurements would tend to "drift" as the light levels varied and/or as the sensor became contaminated.

The LED is strobed in synchronism with the shutter of the linear array so that the LED is only "on" when the shutter is open. Strobing the LED allows the use of a much higher LED drive current. This produces a higher light intensity. The higher light intensity also permits a much faster shutter speed, minimizing the amount of noise caused by the movement of the yarn and/or the ambient light.

The pixels in a linear array typically have a gap between them. This gap is not part of the pixels "active" photo diode area and creates a deadband, i.e., a zone in which

changes in the projected image of the object are not reflected in corresponding changes in the analog output of any of the pixels. This "deadband" limits the resolution of the sensor.

As is shown in Figure 2, the deadband can be eliminated and resolution improved by rotating the linear array at an angle to the yarn. With this arrangement, any change in the image of the yarn always results in a corresponding change in the analog output levels of the associated pixels.

Measurement resolution is also enhanced through calibration. This calibration compensates for gain and offset variations from pixel to pixel, variations in the incident light from the LED upon each pixel and contamination on the lens of the sensor. The sensor is calibrated by reading the array when there is no object, such as the yarn, between the array and the LED. Using this data, gain and offset correction factors are calculated that are applied to the "uncompensated" (raw) pixel data. The compensated pixel output data will be equal when no object is present between the array and the LED.

Example No. 1
Yarn Interlace Measurement

A yarn interlace measurement is an absolute measurement of the number of nodes per meter created by entangling the yarns filaments as the yarn passes through an interlace jet. To calculate interlace, a group of samples, such as 1,024 points, of the variation in the yarn's diameter created by the nodes. A FFT is then used to process the group of samples in order to extract the frequency (nodes/second) of the variation in the yarns diameter created by the nodes. Given the yarn speed (meters/minute) the calculation of the interlace in nodes per meter is as follows:

Interlace = Node Freq (nodes/sec) x 60 (secs/minute) / Yarn Speed (meters/minute)

Example No. 2

Yarn Diameter Measurement

Yarn Diameter is measured as a relative or absolute measurement of the width of the yarn determined by the number of pixels blocked by the yarns shadow projected on to the linear array. A blocked pixel is one whose analog voltage is below a predetermined threshold. The measurement resolution is increased by taking the mean of the sum of 10,000 samples. An absolute measurement (µm) can be obtained by calibrating the sensor with a known standard such as placing a gage pin between the LED and the linear array.

Example No. 3

Yarn Denier Measurement

Yarn Denier is measured as a relative or absolute measurement of the mass of the yarn in units of denier - 1 denier = 1 gram per 9,000 meters. An absolute measurement is obtained by calibrating the sensor while known "good" product is being measured.

Yarn Denier = Yarn Diameter

Example No. 4

Yarn Density Measurement

Yarn Density is measured as a relative measurement obtained by measuring the amount of light passing through the center of the yarn. For this measurement, the "center most" blocked pixel output(s) is used as a relative measure of the yarn density.

Example No. 5

Yarn Density Measurement

Filament Orientation is measured as a relative measurement proportional to difference between the amount of light passing through the center of the yarn and the yarn denier.

Filament Orientation = Yarn Density - Yarn Denier

Example No. 6

Yarn Broken Filament Measurement

Broken Filaments can be measured because multiple shadows are projected onto the linear array instead of just a single shadow. Broken filaments are detected by scanning the array for multiple shadows.

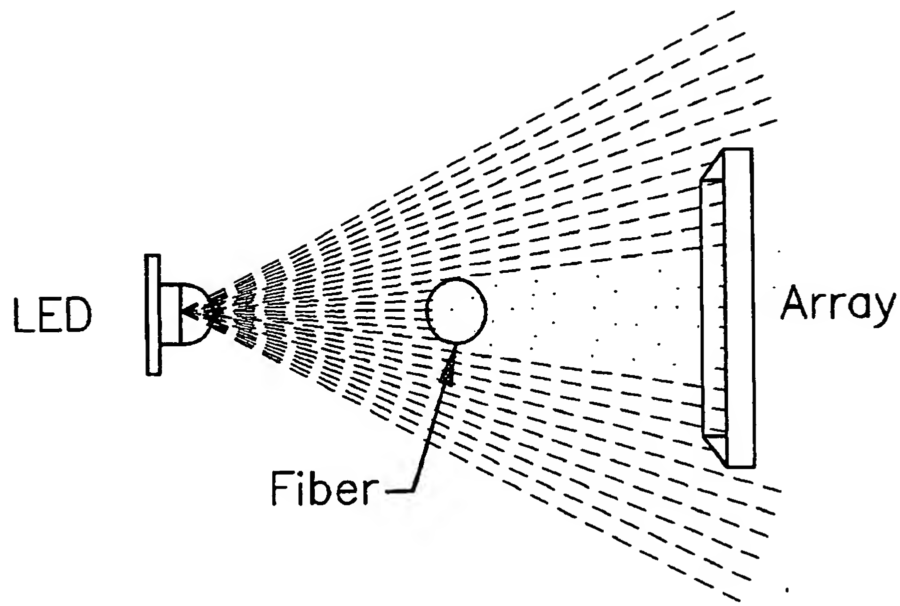

Figure 1 Optical Sensor Measurement Geometry

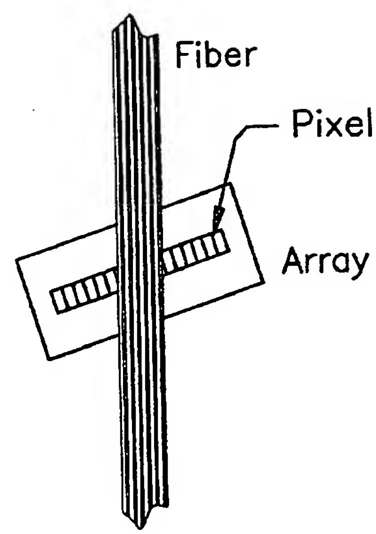

Figure 2 Array Orientation for Increased Resolution

Application Data Sheet

Application Information

Title Line One::	OPTICAL SENSOR FOR MEASURING
Title Line Two::	CHARACTERISTICS AND PROPERTIES OF
Title Line Three::	STRANDS
Attorney Docket Number::	3102/1
Total Drawing Sheets::	2
Formal Drawings?::	No
Application Type::	Provisional
Subject Matter::	Utility
Small Entity?::	Yes

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